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## Level Control Systems

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## Model: Level Control Systems

Production: E32 750iL 88-94 (Hydro-Pneumatic)

E32 740iL 93-94

E38 750iL 95-01

E38 740iL 95-01

E34 Touring 525iT, 530iT

E39 Touring 528iT, 540iT, 525iT (EHC I)

E53 X53.0i, X5 4.4i and X5 4.6is (EHC I)

E53 X5 3.0i, X5 4.4i (EHCII)

E66 745Li, 760Li from 03 EHC

### Objectives:

After completion of this module you should be able to:

- Identify BMW Level Control Systems

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## Air Suspension Systems (EHC)

### Purpose of the System

Air Suspension systems were first introduced on the 1999 E39 Sportwagon. Since then the E53 (X5) and E65/E66 (7Series) models were available with this new system. EHC are available in two configurations, the Single Axle Air Suspension System and the Dual Axle Air Suspension System. The Dual Axle (EHC II) system is only available on E53 X5 models from the 2002 model year.

EHC systems can be found on the following vehicles:

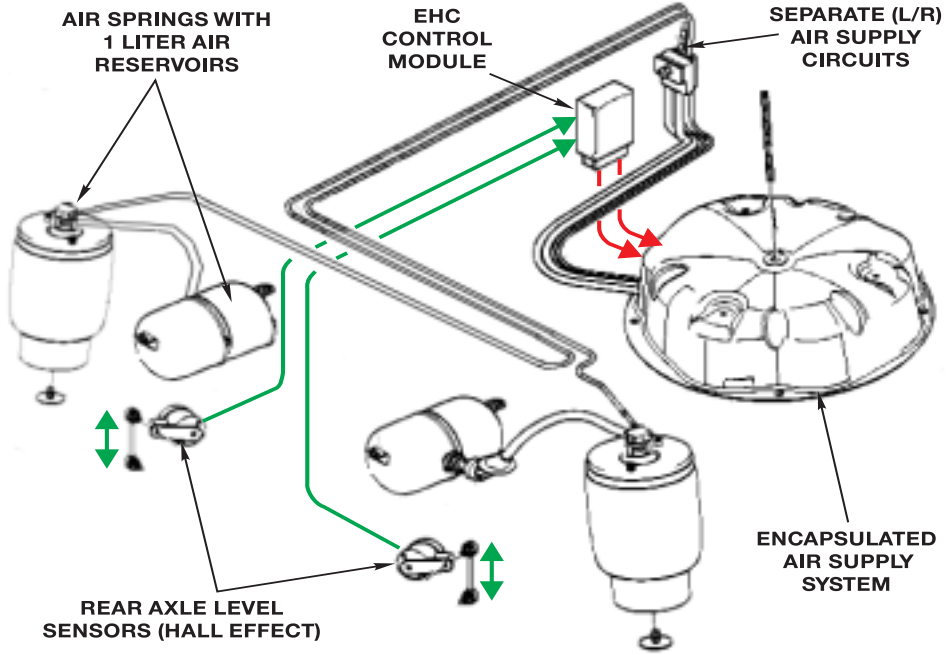
- E39 Sportwagon 528i, 525i and 540i from the 1999 Model Year (Single Axle)
- E53 X5 3.0i and 4.4i from the 2000 Model Year (Single Axle)
- E53 X5 4.6iS from 2002 (Single Axle)
- E53 X5 3.0i and 4.4i from 2002 (Dual Axle EHC II)
- E65/E66 from 2003 Model Year (Single Axle)

There are some functional changes with these systems. On EHC, the entire axle load is borne by the air suspension. The underlying control philosophy of EHC is "Control only when absolutely necessary". This means that brief changes in the ride height are not compensated (such as potholes). This avoids any unnecessary control operations.

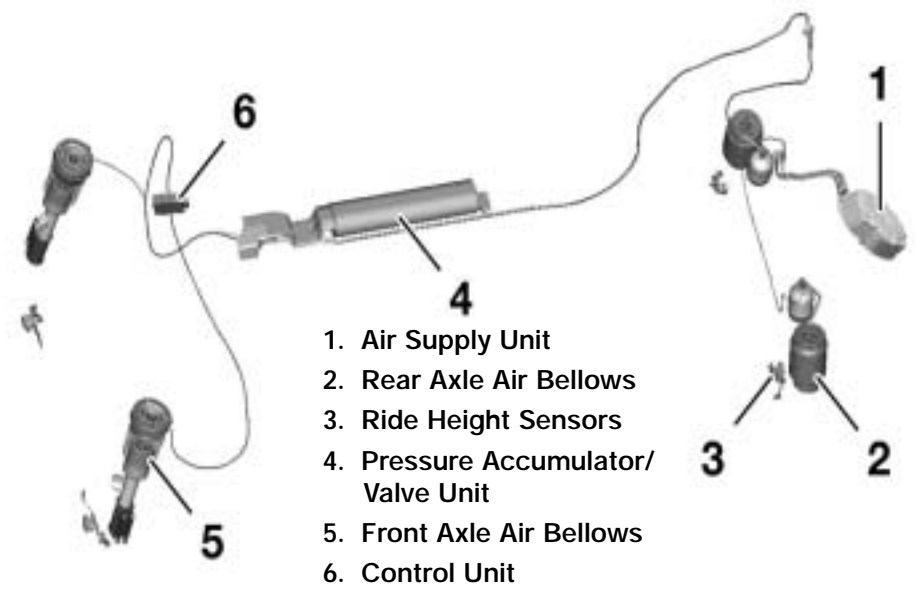
The advantages of air suspension are as follows:

- Control is independent of the vehicle engine
- Single-wheel control is possible
- Lateral locking is affected
- A distinction is made between load and drive states
- An inclined load is identified and corrected
- However, an inclination is not compensated
- Self diagnosis can be performed
- Diagnosis with DISplus or GT-1 is possible
- An automatic interruption of control takes place in case of cornering and wheel changes.

# EHC System Overview



EHC I Single Axle Air Suspension E39/E53



EHC II Dual Axle Air Suspension E53

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## Single Axle EHC I System Components (E39/E53)

The EHC system consists of the following components:

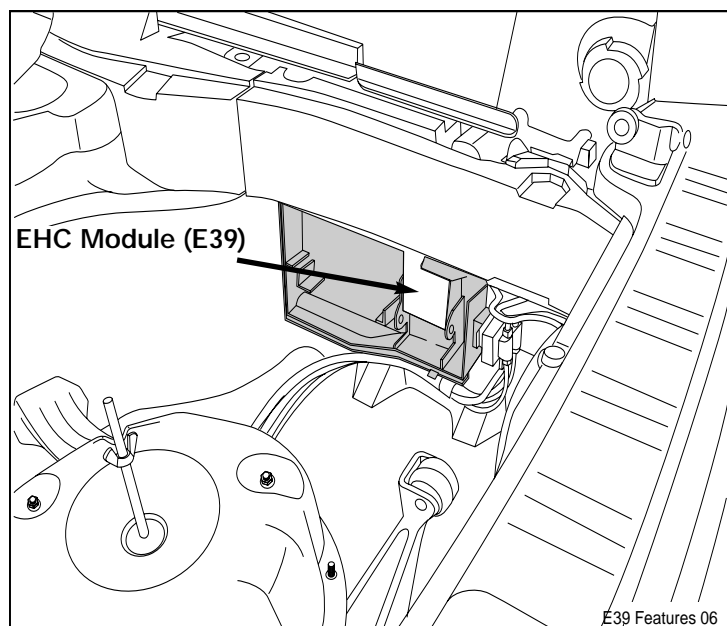
- EHC Control Module
- Air Springs (2) with Air Reservoirs
- Rear Axle Level Sensors
- Encapsulated Air Supply (LVA)
- Warning Indicator

### Control Module

The Control Module is mounted in the module carrier box in the luggage compartment on the right side. It contains the processing electronics and final stages for operation of the EHC system.

The control module receives the following inputs for its processing functions:

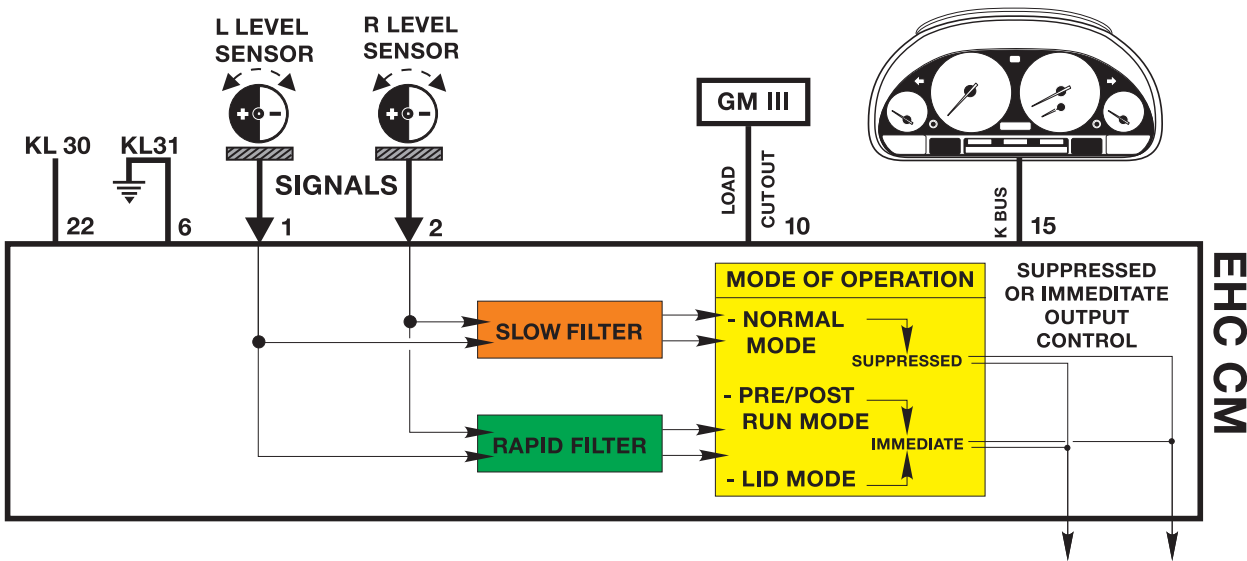
- KL 30 & 31 (Power/Ground)
- KL 15
- Left & Right Ride Height Sensors
- K Bus for;
  - Vehicle speed
  - Engine running
  - Door/tailgate - open/closed



The control module incorporates two filters (slow/rapid) for processing the input signals from the ride height sensors. Depending on the operating mode, either the slow or rapid filter is used to check the need for a regulating sequence.

The slow filter is used during the normal operation mode to prevent normal suspension travel from causing the system to make adjustments.

The rapid filter is used during the pre-run and tailgate (LID) modes to ensure that the suspension is adjusted quickly while the vehicle is being loaded or checked prior to operation.

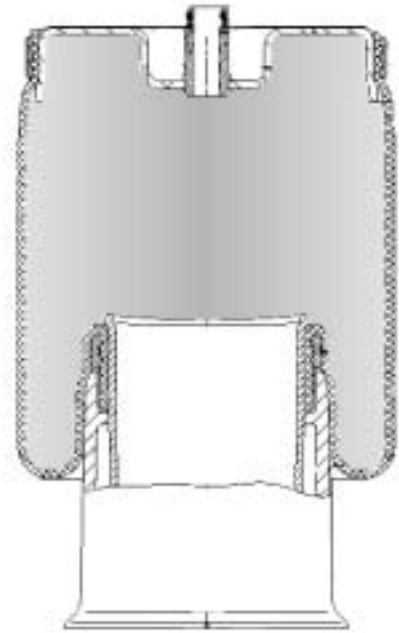


## Air Springs

The air spring is made from a flexible rubber material. It forms an air tight cavity which provides the calculated spring rate required for the sport wagon.

As the spring compresses downward the bottom edge of the rubber material rolls along the vertical surface of the base mount cylinder.

Air is added or removed from the air spring through its top port. The top port of each spring is connected to a reservoir and the air supply pipes. The reservoirs are required to hold additional air due to the compact design of the springs.

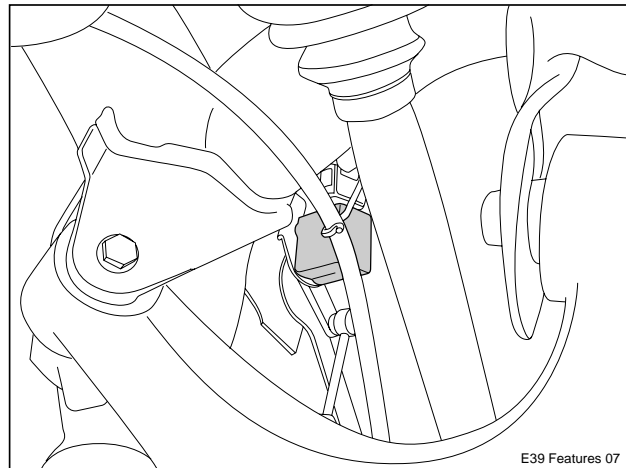


## Rear Axle Level Sensors

Hall effect sensors are mounted on the left and right sides of the rear suspension for ride height detection. They are pivoted by a coupling rod through the rear axle swing arms.

The hall sensors produce a varying voltage input to the control module as the suspension height changes.

If the vehicle is equipped with Xenon headlights the right side sensor contains an additional sensor for the automatic headlight level adjustment system.

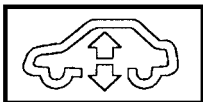


## Warning Displays

If the system is faulted and off-line or set in the transport mode, the following is displayed:

**Basic Cluster:** A warning lamp indicator is illuminated used on the basic cluster.

**High Cluster:** A message is posted in the high cluster matrix display.

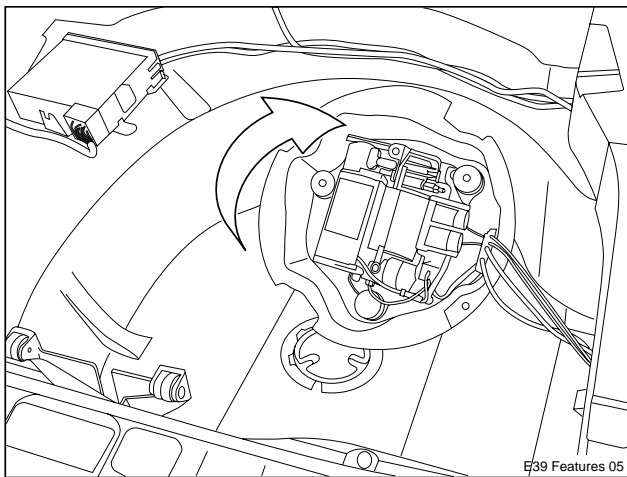


## Air Supply System (LVA)

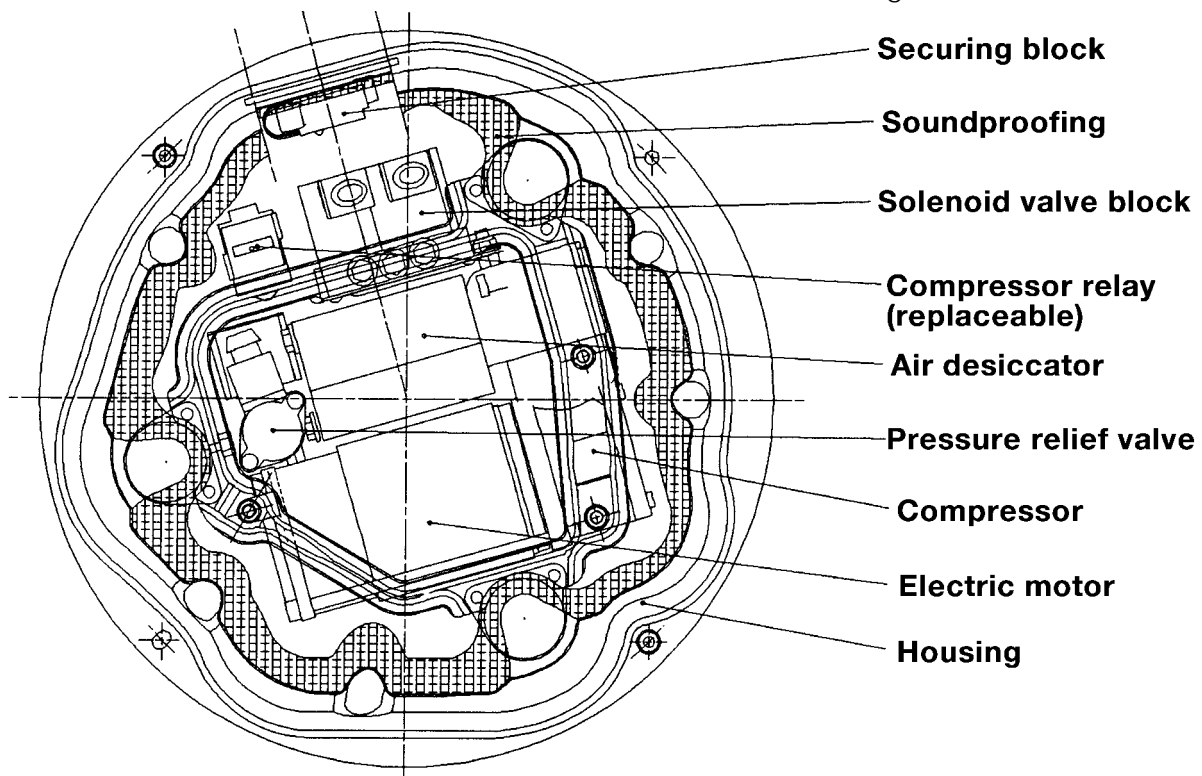
The air supply system is identified as the LVA in the diagnosis program and in the repair manual. It is mounted in the spare tire well compartment. The components are housed in a sound deadening carrier, through rubber bushings, to prevent operating noises from being transmitted through the vehicle's interior.

With the exception of the compressor relay, individual replacement parts for the air supply system are not available. If diagnosis determines a defect in any of the other air system components, complete replacement is necessary.

The air supply system consists of the following components:



- Compressor assembly with;
  - Piston compressor
  - Electric motor
  - Air dryer (desiccator)
  - Pressure relief solenoid valve
  - Pressure maintenance valve
  - Check valves
- Compressor Relay (Replaceable)
- Solenoid Valve Block (2 - two way valves)
- Lines - including distributor





## Air Supply System (LVA) Operation

The single stage piston compressor produces a maximum pressure of 13.5 Bar. The compressor is maintenance free - provided it is used in a dust free environment. This includes the compressor's intake air filter.

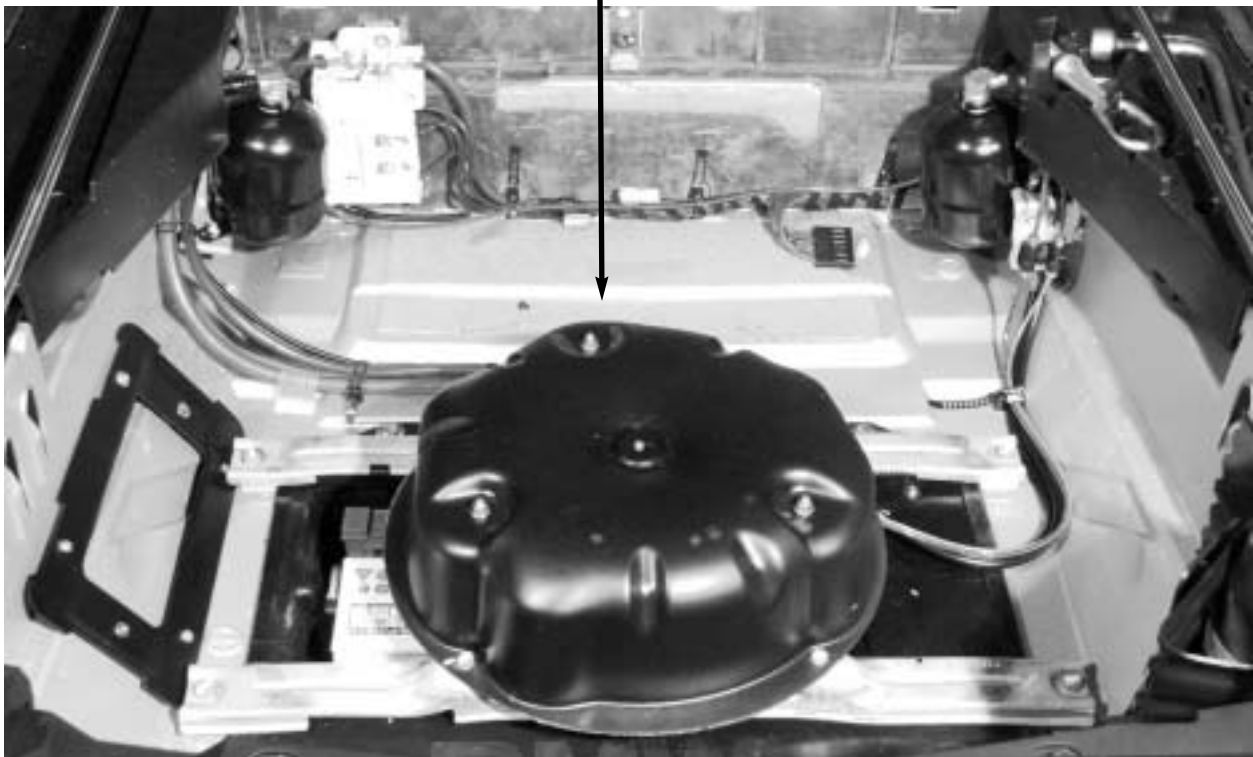
The compressor is driven by a DC motor that is controlled by the compressor relay through the control module.

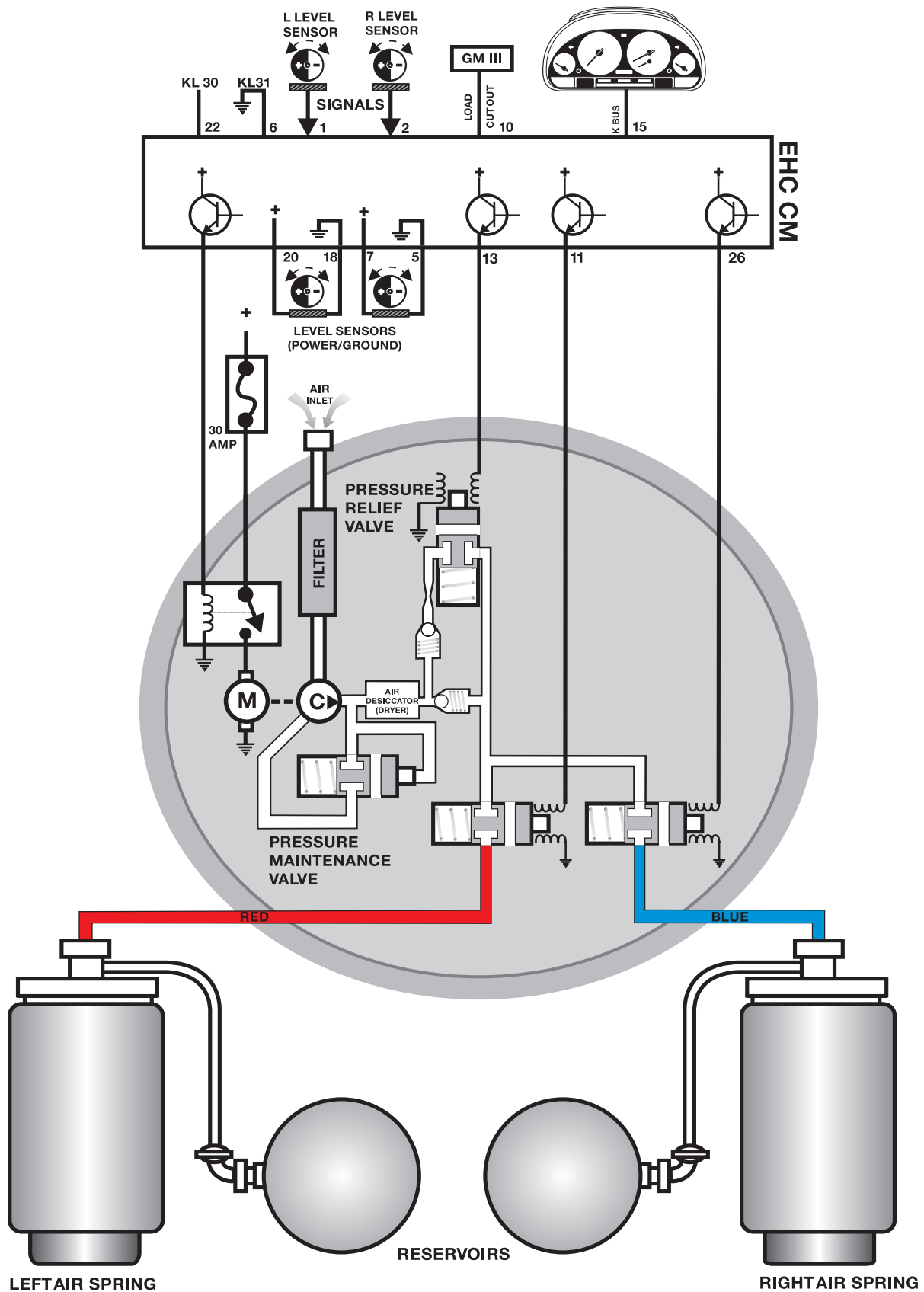
When the compressor is activated, the pressure builds up to a working pressure of 11.4 Bar (+0.8/-1.5 Bar). This is controlled through the pressure maintenance valve. The air under pressure is fed through the dryer and check valve to the solenoid valve block for the air springs.

There is one solenoid valve in the valve block for each air strut. This allows the system to compensate for uneven loads in the vehicle and maintain the vehicles ride height at all times.

Pressure is drained through the left or right solenoid valve (energized open) the pressure relief solenoid valve, restrictor, check valve and dryer back to the inlet side of the compressor pump.

LVA Location X5





## EHC System Operation

A fully functional EHC system is controlled by one of three different modes of operation. The operation mode is selected by the control module based on current conditions provided by the monitored input signals. The main modes of operation are:

- **Pre-Run/Post-Run Mode**
- **Normal Mode**
- **Tailgate Mode**

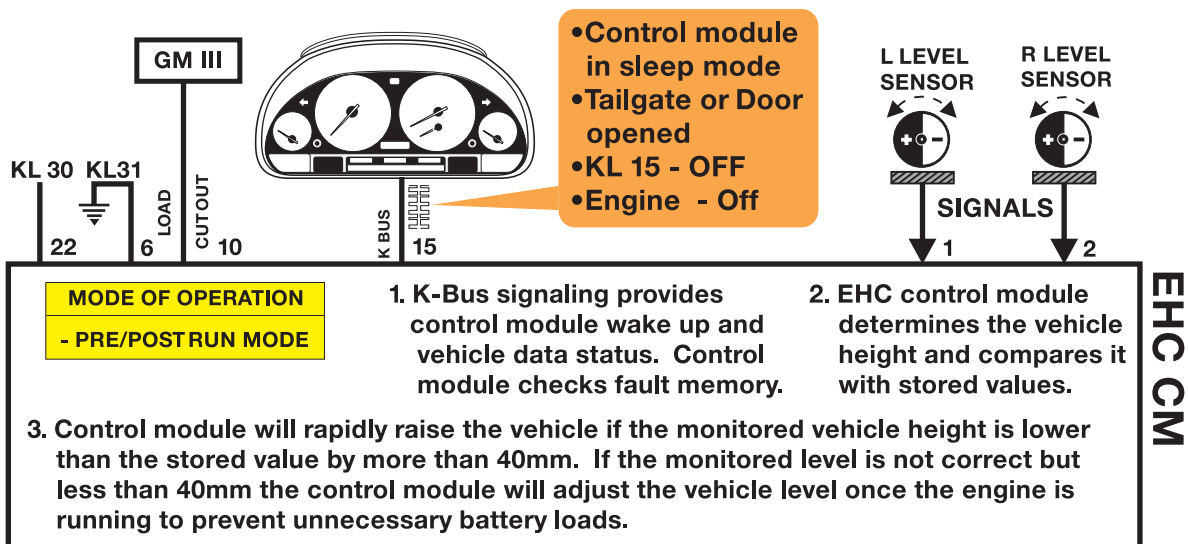
Two special operating modes are also included in the control module programming.

- **New/replacement mode** (pre ZCS encoded). This mode provides basic operation.
- **Transport Mode** - Transport mode is set at the factory and raises the vehicle 30mm to prevent vehicle damage during transportation. It must be deactivated with the DIS/ MoDiC prior to customer delivery.

### Pre-Run / Post-Run Mode

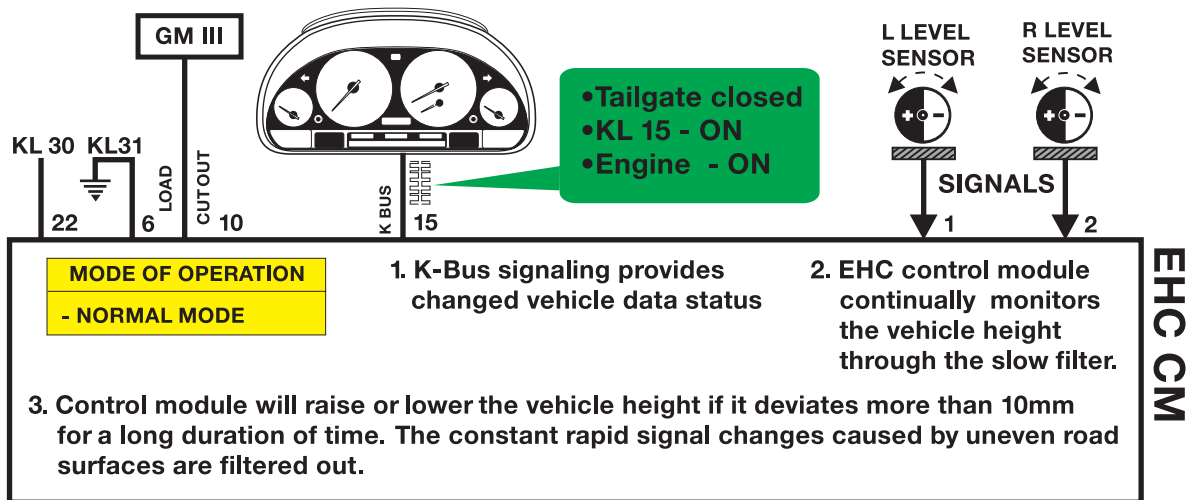
The Pre-Run mode is activated when the vehicle is parked and the control module is in the sleep mode. Opening a door or the tailgate initiates a system wake up and the control module comes on-line.

The control module performs a self-check of the control electronics and sensors. If no fault is found, the system will check the ride height and institute a rapid regulation if the height varies by more than 40mm.



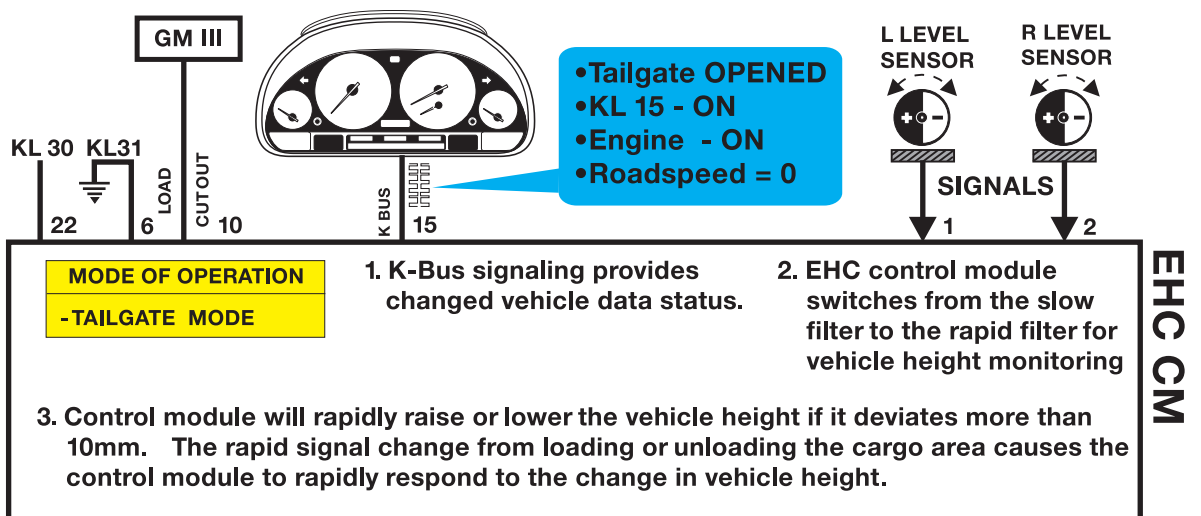
## Normal Mode Operation

Once the rear lid is closed, KL 15 switched ON and the engine started, the system switches into the normal operation mode. In the normal mode, the control module will constantly monitor the input signals from the ride height sensors and will activate a correction if the ride height deviates by at least 10mm.



## Tailgate Operating Mode

The tailgate operating mode is activated if the gate is opened with KL - 15 On and the engine running. The difference between this mode and the normal operating mode is the response time is rapid instead of slow.



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## Special Operating Modes

- **Assembly Line Mode (New control module)**

The assembly line mode refers to control module manufacturing. New control modules are stored in a deactivated state. The control programming is not active and must first be ZCS encoded.

After installing a replacement control module, it must be coded using the DIS or MoDiC. The instrument cluster fault display will remain illuminated until the control module is coded.

- **Transport Mode**

The vehicle rolls off the factory assembly line with the EHC control module in the transport mode. The transport mode inflates the air springs to a higher position (approx. 30mm higher) than the normal mode in order to avoid damage during transit.

The system will not respond to any inputs that would alter the height of the vehicle. The fault indicator (base cluster) is illuminated or instrument cluster matrix display (high cluster) provides the message "Leveling System" to draw attention to the transport mode setting.

The Service Functions section of the diagnosis program is used to activate/deactivate the transport mode. Once the transport mode is deactivated, check the vehicle Ride Height Offset making sure the vehicle rear axle height is to specification.

## Control Interrupts

### Cornering

To prevent unnecessary suspension adjustments while driving through corners, a "control interrupt" is built into the system. Above 30MPH the control module monitors the left/right ride height sensors for a difference of 30mm. Exceeding this difference will put the system into a control interrupt and no adjustment will take place. The control interrupt last for a duration of 5 minutes.

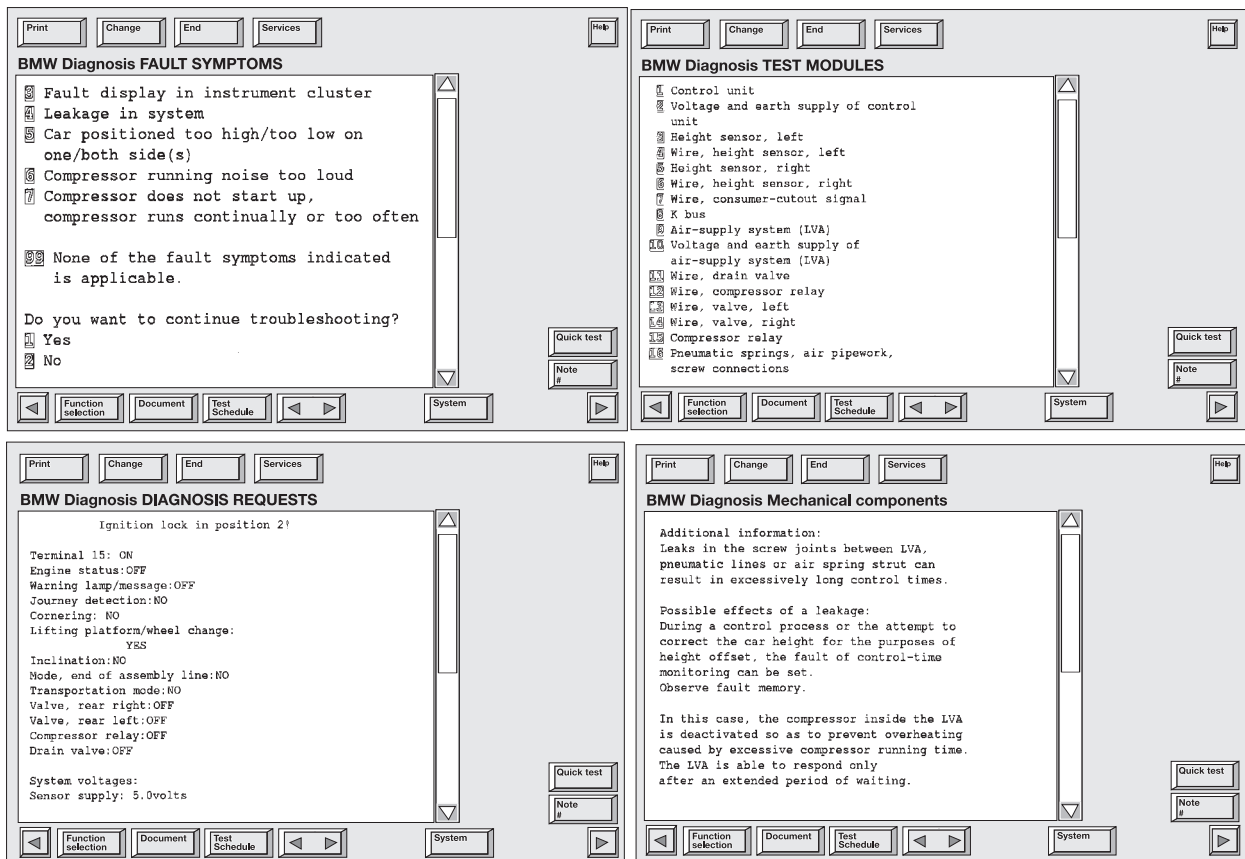
### Vehicle Lifting

The ride height control is interrupted when the vehicle is raised on a lift or with a jack. The system monitors the ride height sensor inputs and when the height limit of 90 mm is exceeded, the control is switched OFF until the vehicle is lowered again.

# EHC Service Information

## Diagnosis/Coding

- The EHC control module is connected to the diagnostic link. The EHC control module activates the fault display in the instrument cluster to alert the operator of the off-line status of the system. The EHC control module stores up to three electrical/electronic faults.
- Diagnosis/troubleshooting of EHC is carried out using the fault symptom troubleshooting program of the MoDiC or DIS. The EHC system has an extensive diagnosis program.
- Replacement control modules are shipped in the factory mode. The control modules must be ZCS encoded using the DIS or MoDiC to activate the operating parameters.



## DISplus/GT-1 Service Functions Program

The Service Functions program of the DIS/MoDiC provides the Transport Mode activation/deactivation and Ride Height Offset functions (see next page).

Once the transport mode has been released, or if the system requires left to right side height adjustment, the ride height "OFFSET" must be carried out to ensure that the vehicles suspension has a base ride height level starting point.

The "HEIGHT OFFSET" is adjusted using the DIS or MoDiC. The procedure is as follows:

- Place the vehicle on a level surface unloaded.
- Access the Height Offset program in the service function menu.
- Measure the base ride height from the lower edge of the wheel housing to the center of the wheel hub.
- Check measured height against the specifications listed
- Use the DIS/MoDiC to correct the ride height if the value differs from the listed specification.

The image displays four sequential screenshots of the BMW Diagnosis HEIGHT OFFSET program interface. Each screen features a menu bar with 'Print', 'Change', 'End', and 'Services' buttons, and a 'Hub' button in the top right corner. The interface includes a large text area for instructions and specifications, and a bottom control bar with 'Function selection', 'Document', 'Test Schedule', and 'System' buttons.

**Top Left Screenshot:** Displays the initial instructions for the height offset procedure. It states: "Press the appropriate keys to move the car to the correct position (measurement with tape measure!). Each key actuation changes the car ride level by 5 to 10 mm. Dimensions apply from lower edge of wheel house to centre of wheel. Specified ride levels: E39 saloon : 360 mm +/- 3mm, E39 touring : 360 mm +/- 3mm, E39 touring with sports chassis : 345 mm +/- 3mm." Buttons for 'Quick test' and 'Note #' are visible.

**Top Right Screenshot:** Provides additional information and instructions. It states: "Additional information: Car must be in the normal position, i.e. in a compensated state. Car must be standing on a level surface. Instruction: One-sided loading and parking on uneven surfaces must be avoided! If necessary, wait until vehicle has corrected itself. Measure distance from lower edge of wheel house to wheel centre with tape measure. Specified ride levels: E39 saloon : 360 mm +/- 3mm, E39 touring : 360 mm +/- 3mm, E39 touring with sports chassis : 345 mm +/- 3mm." Buttons for 'Quick test' and 'Note #' are visible.

**Bottom Left Screenshot:** Shows the final selection screen. It lists the specified ride levels for 'sports chassis : 345 mm +/- 3mm' and asks: "Check: Is the vehicle height in the specified range?" with options for 'Yes' and 'No'. Buttons for 'Quick test' and 'Note #' are visible.

**Bottom Right Screenshot:** Displays the final selection options: 'Left Δ', 'Left ▽', 'Right Δ', 'Right ▽', and 'Height O.K.'. Buttons for 'Quick test' and 'Note #' are visible.

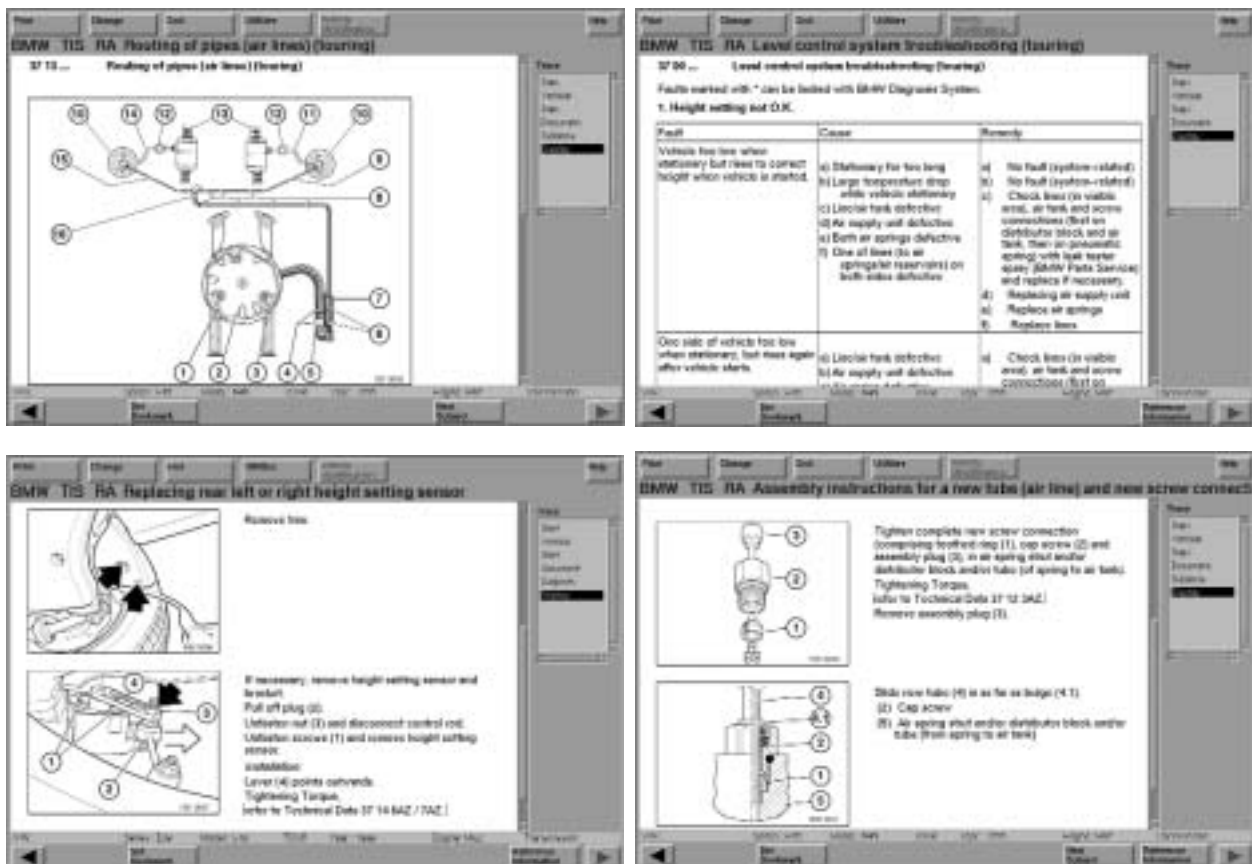
## TIS Repair Manual Information

The repair manual contains the following EHC specific sub-group repair information:

- 00 General (general information, overview routing of pipes, tubes and components)
- 12 Control and suspension system, rear (DIS referral, specific R&R procedures, etc.)
- 13 Connecting Lines (specific R&R procedures)
- 14 Electrical components (specific R&R procedures)
- 22 Pump assembly (LVA) with container (LVA R&R procedure)
- 90 Troubleshooting (system troubleshooting charts)

The troubleshooting charts provided an additional reference when used in conjunction with the DIS program.

The following screen sample are from the TIS repair manual section.





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## **Two Axle Air Suspension (E53 EHC II)**

### **Purpose of the System**

The two axle air suspension system (EHC2) offers advantages over the single-axle air suspension with respect to ride comfort and off-road capability.

Lowering the entire body makes it easier to enter, exit, load and unload the vehicle. The vehicle's off-road capability was improved by providing the possibility for increasing the ground clearance of the body.

The driver can now choose between three different ride levels which can be set with a rocker switch, as required. Automatic ride-height control for payload compensation and automatic inclination compensation continue to be fitted.

### **Deficits of the old system**

The automatic payload compensation facility for the single-axle air suspension did not permit driver control. The driver could not actively control the system to make it easier to enter and exit or load the vehicle.

Ride level was compensated via the rear axle only.

### **Advantages of the new system**

The new system allows the ride-height control system to be controlled actively by the driver.

The twin axle air suspension allows both axles to be lowered evenly and in parallel. As a result, it is easier for the occupants to enter, exit, load and unload the vehicle.

On the E39, the load of the complete rear axle was born for the first time by air suspension in combination with the optional ride height control system. The system was controlled automatically under all operation conditions, and there was no possibility for driver intervention on the X5, the rear axle previously had single axle air suspension only. The air supply unit and the control unit were adopted from the E39. The air springs were adapted to the X5.

There is a standard version and a sports version.

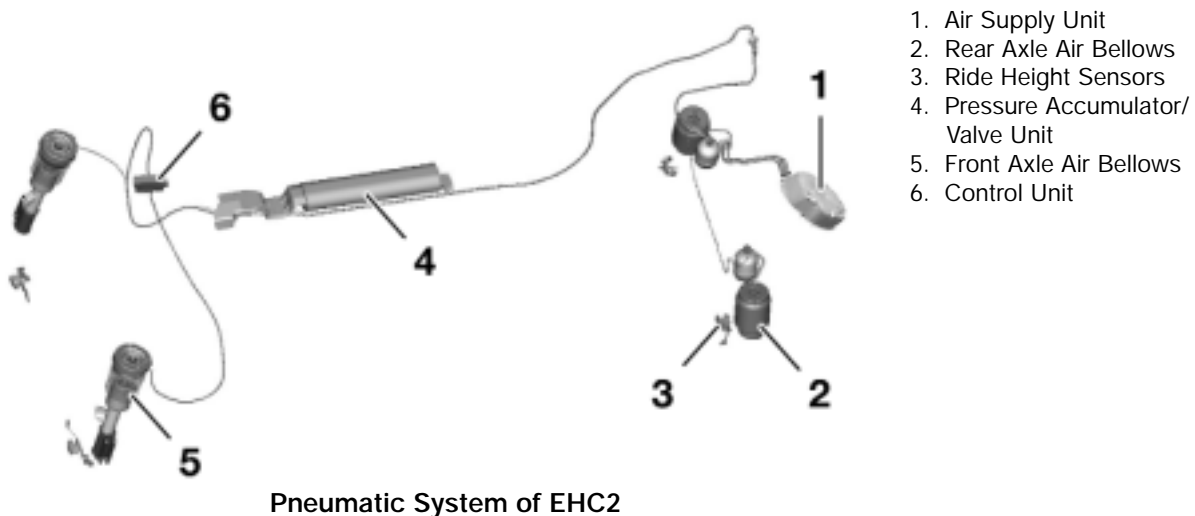
The ride-height control system (EHC) was supplied as standard in combination with the M62 engine and is available as an optional extra in combination with the M54 engine.

EHC2 is optional on both the M62 and M54 versions of the X5 and not available on the 4.6is X5.

## System components

The X5 Two Axle Air Suspension System (EHC2) utilizes the air supply unit from EHC mounted in the luggage compartment, with the following components added or modified:

- Air Supply Unit (with redesigned compressor and drier)
- Pressure Accumulator
- Valve Unit
- Ride Height Sensor
- Air Suspension Strut
- Control Unit
- Switch Assembly



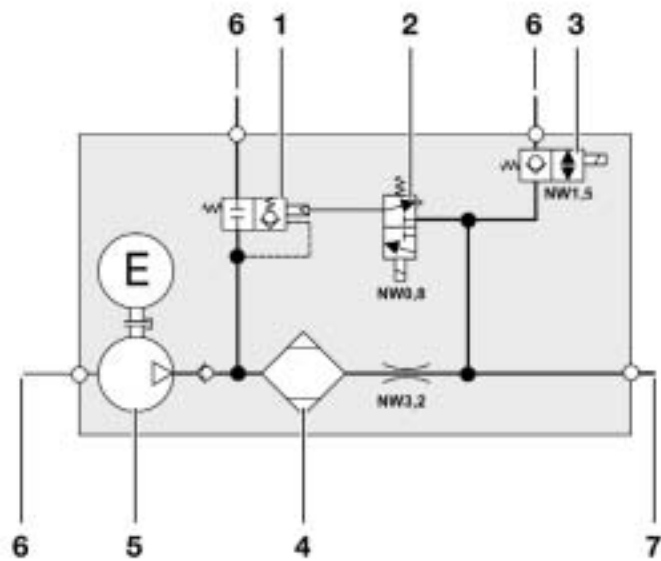
## Air Supply Unit

As on vehicles with single axle air suspension, the air supply unit is located in the luggage compartment under the spare wheel. As with the single axle air suspension, the auxiliary tanks for the rear air spring bellows are located in the luggage compartment.

The air supply unit is configured similarly to the single axle air supply unit for the ride-height control system of the E39, which is currently in production.

The functions are implemented by activating a compressor and various valves in the air supply unit and on the air accumulator valve unit.

The maximum pressure of the air supply unit is 21 bar.



1. Pneumatic Drain Valve
2. Electric Pilot Control Valve
3. High Pressure Vent Valve
4. Air Drier
5. Compressor
6. Sintered filter
7. To Pressure Accumulator/Valve Unit NW Size of opening/tubing in mm.

**Air Supply Unit**

### **Pneumatic Drain Valve**

The Pneumatic Drain Valve is activated pneumatically by pressure from the control valve. This causes the drain valve to open allowing the pressure supply line to vent to atmosphere. This design allows for large air volumes to be discharged quickly and eliminates the need for a solenoid valve with high current consumption. The 21 bar pressure limiting valve is integrated in the drain valve.

### **Electric Pressure Relief Valve**

The electrically activated pressure relief valve controls normal system pressure. The control valve performs this function in conjunction with the drain valve.

### **High Pressure Vent Valve**

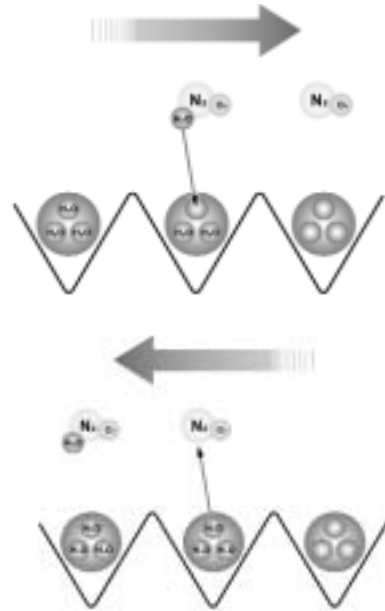
The High Pressure Vent Valve serves as a comfort valve and is used to release system pressure after the accumulator has closed and the compressor is still running. When the high pressure vent valve has opened the compressor can be stopped quietly.

### **Air Drier**

In the air drier, the air which is drawn in passes over a water absorptive filter material in the form of filter nodules which extract moisture from the air. As long as the air contains more moisture than the filter material, the individual nodules absorb and accumulate the moisture. When the air flows back, it is drier than the filter material, with the result that the air is re-humidified and the moisture is discharged into the open air. The maximum water storage capacity of the filter is 30 g.



Compressor with Drier



Top: Air Drying

Bottom: Dissipation of water to air

## Compressor

Compressor operation is the same as in EHC with the following technical improvements:

- Addition of a temperature sensor (Located on the compressor cylinder head)  
Temperature sensor switches off the compressor at temperatures above 110°C.
- Extended compressor ON time (180 seconds)
- Redesigned air drier to compensate for additional air volume.

## Pressure Accumulator

The twin axle air suspension system now features a pressure accumulator which forms an air accumulator valve unit in combination with the valve. The air accumulator valve unit is located beneath the vehicle floorpan in the right-hand sill area.



↑  
Pressure Accumulator Unit which includes:  
Pressure Accumulator  
Pressure Sensor  
Valve Unit

Front

The pressure accumulator decreases the load on the compressor and significantly reduces the time required for large changes in ride height.

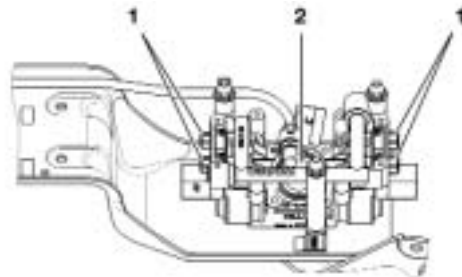
The EHC 2 control module monitors system pressure via a pressure sensor mounted on the accumulator. Normal system pressure is 15.7 +/- 0.7 bar. Minimum system pressure is 9 bar.

The pressure accumulator's charge is sufficient to fill the four suspension struts once from the Access position to the normal position and compensate for vehicle load up to maximum gross weight.



### Accumulator/Valve Unit

1. Air Lines  
Yellow-Black Front  
Red-Blue Rear
2. Pressure Accumulator
3. Connecting Cable
4. Pressure Sensor
5. Valve Unit



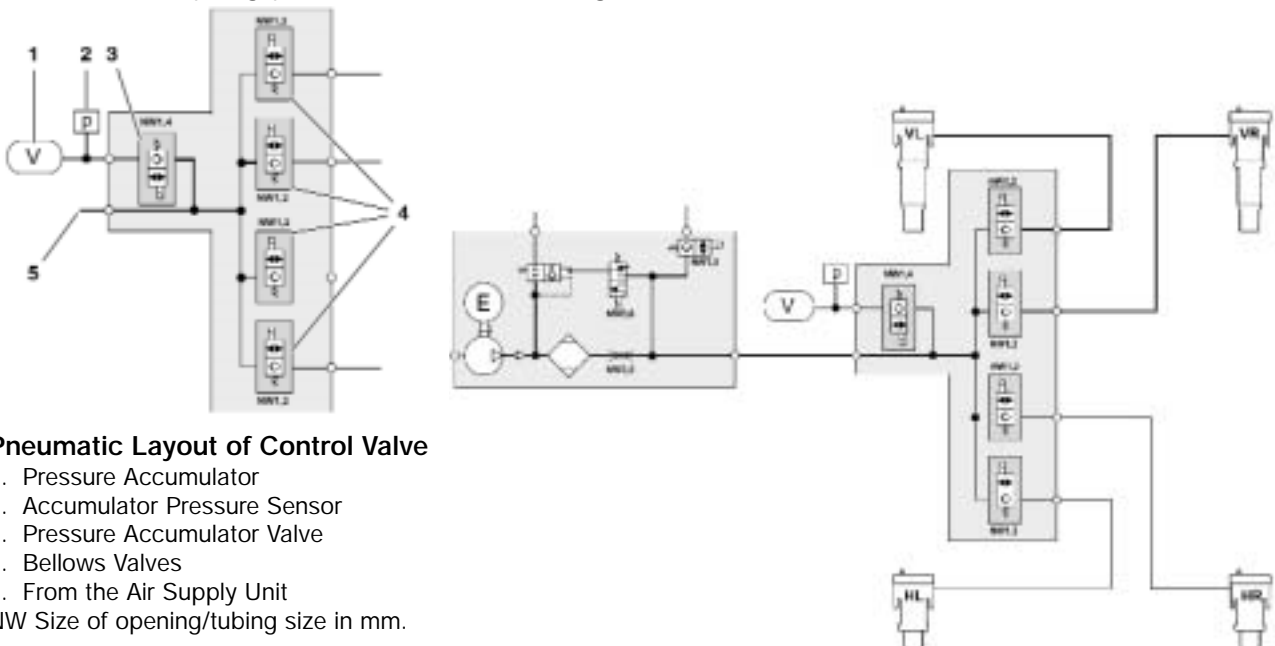
### Valve Unit

1. Connections for Air Lines
2. Pressure Accumulator valve

### Valve Unit

In the valve unit, four bellows valves and the pressure accumulator valve are activated.

The bellows valves and the pressure accumulator valve are solenoid valves which are closed under spring pressure when de-energized.

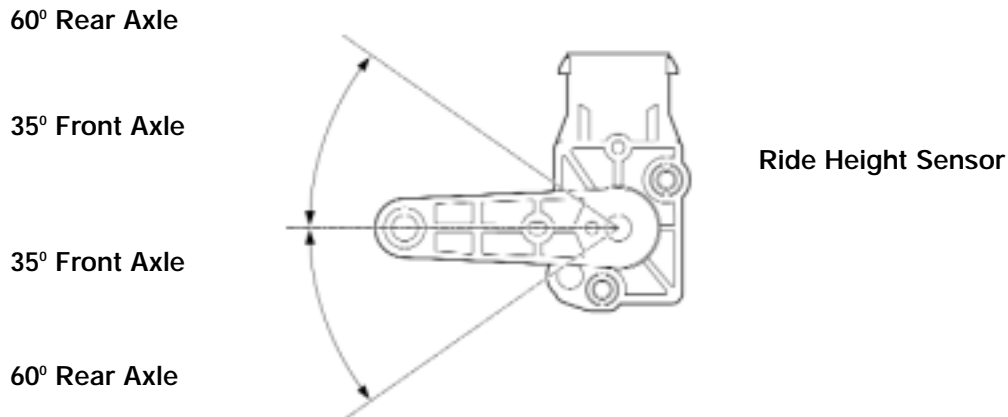


### Pneumatic Layout of Control Valve

1. Pressure Accumulator
  2. Accumulator Pressure Sensor
  3. Pressure Accumulator Valve
  4. Bellows Valves
  5. From the Air Supply Unit
- NW Size of opening/tubing size in mm.

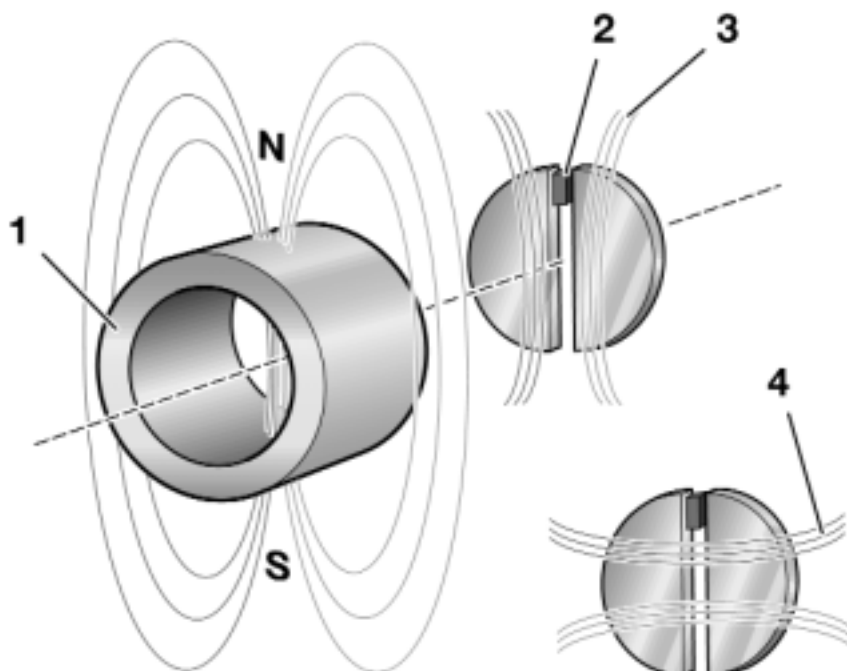
## Ride Height Sensor

The control unit obtains information about the ride height of the vehicle via a ride height sensor attached to each of the four wheels.



The ride height sensor is an angle Hall sensor which is activated by a ring magnet. The ring magnet is polarized vertically from north to south.

The magnetic field line of the ring magnets intersect a Hall cell. The Hall cell is arranged in such a way that only the horizontal components of the field lines are evaluated. This results in different field line strengths at different positions of the ring magnet. The Hall cell measures the field strength of the magnetic flux and converts it into an analog signal with a voltage level between 0.5 and 4.5 V.



### Sensor Principle of Operation

1. Ring Magnet
2. Hall Cell
3. Longitudinal magnetic field lines, low voltage 0.5V
4. Transverse magnetic field lines, high voltage 4.5V

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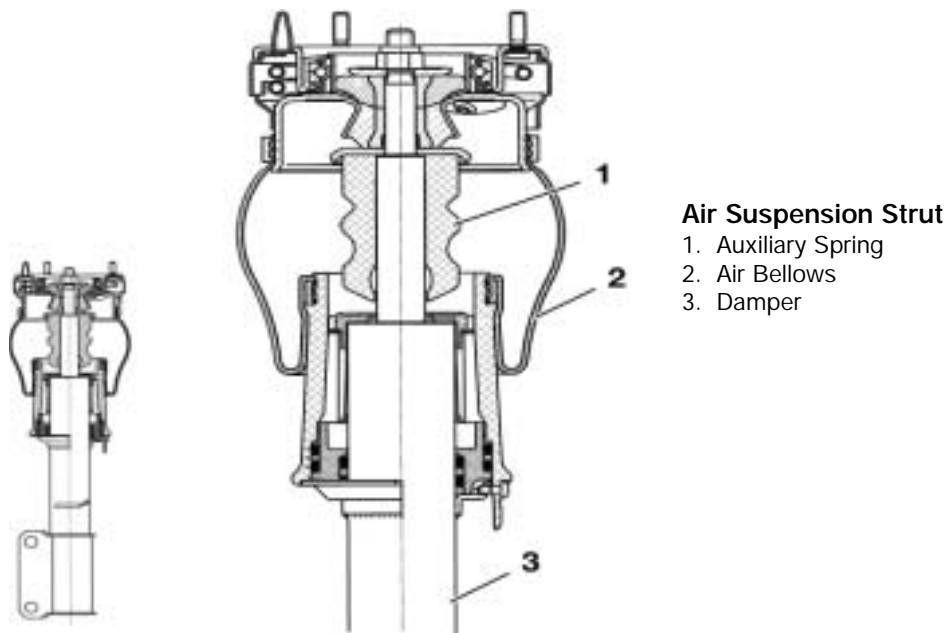
## Air Suspension Strut

### Rear

Minor modifications were made to the rear axle air springs. The air springs and the dampers are configured separately at the rear axle.

### Front

The air suspension replaces the steel suspension at the front axle, i.e. the spring bellows is attached to the damper. The front air suspension strut and the impact absorber form a complete unit.



### Control Unit

The EHC2 Control Unit is located behind the glovebox adjacent to the General Module. The connector is a black 54 pin connector.

Inputs received directly into the control unit are:

Ride Height Level Sensor (X4)	Up and Down requests from the switch assy.
General Module (Load cutout signal)	CAN Bus Inputs
K Bus Inputs	Pressure Sensor
Compressor Temperature	

### Outputs include:

Air Unit Control (Activation)	Front and Rear Axle Valves
LED's for Switch Unit	Compressor Relay
Pressure Accumulator	

